Chapter 5. Barometer Basics: A Structured-Inquiry Activity

Think About This!

Have you ever gone up a hill or mountain in a car or flown in an airplane and had your ears "plug up" or ache? Why do you think it happens?

Examine the eardrum in Figure 5-1.

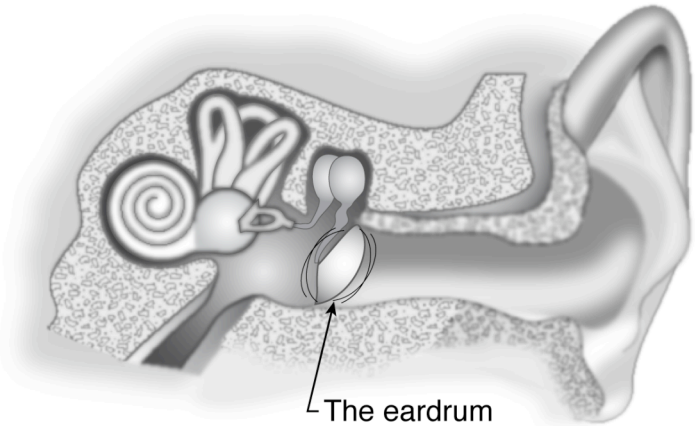

Figure 5-1. Cross section of the ear.

Do they plug up when you go up as well as when you go down? How do you think this effect on the ear can be explained? If it happens when going up as well as going down, are the factors that cause this problem responding in the same way? How do you know? How could you test this process?

Probing Further

Important basic concepts in meteorology have to do with understanding that air has weight, that the density of air changes as temperature changes, that cooler air is denser than warmer air, and that unequal heat distribution causes movements of air. The following series of activities focuses on the construction of basic meteorological instruments and other devices enabling the learner to explore basic factors that form the foundation of weather study. Many of these activities will help the learner better understand the basics of weather through exploring how the constructed instruments function and then applying the instrument to explore important basic meteorological content. Some activities will provide the learner with the opportunity to examine abstract concepts in a more concrete manner, thus eliminating some common weather misconceptions.

Materials

2 large rubber balloons

2 pint canning jars

2 rubber bands

Heat lamp
(or lamp on stand
with 150-watt bulb)

Safety glasses

Access to
refrigerator/freezer or large shallow
container with water and ice

Objectives for the Learner (Essentials of Inquiry)

Conceptual Theme: To develop a basic understanding of the interrelationship between temperature and pressure and the structure of a device made to examine this relationship.

Content: Developing basic information relating to temperature and pressure and its importance to the study of meteorology.

Skills: The focus is on the handling of laboratory equipment, making careful observations, recording pressure differences, making conclusions, and describing and communicating results.

Scientific Habits of Mind: The importance of careful observations, respect for data, verifying results and conducting experiments safely.

Preparation

Place the two canning jars on a flat surface and allow the air inside to adjust to the temperature of the air in the room. This process might take 10 minutes.

While waiting, cut the necks off both balloons at their expansion points. Carefully stretch one balloon over the mouth of one pint canning jar and pull tightly across the mouth of the jar to remove all wrinkles in the balloon surface as shown in Figure 5-2. Place a rubber band around and near the top of the jar to hold the balloon firmly in place. This stretched balloon represents a "responding diaphragm." Repeat this procedure for the other canning jar.

Make careful observations and record the condition of both balloons before carrying out the next steps.

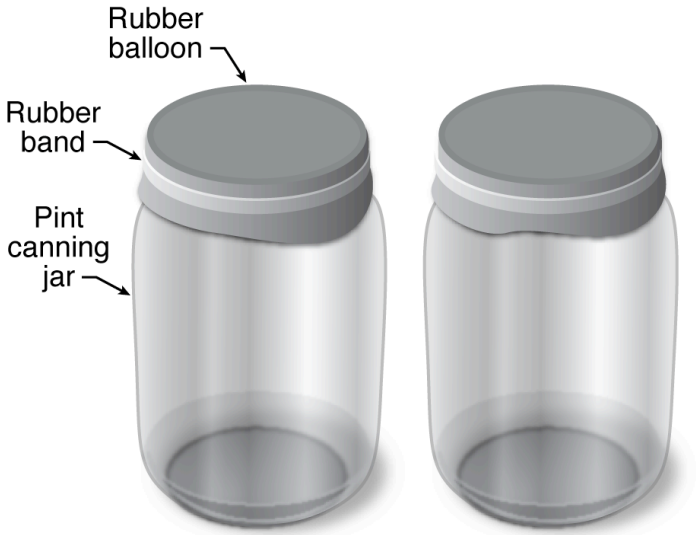

Figure 5-2. Experiment setup.

Place one of the prepared jars into a freezer or place it in a shallow container with ice cubes and water. The water level should be about 2 inches from the bottom of the container. Place the other jar near a light source (a heat lamp or lamp with 100-watt bulb). Allow the jars to remain in these two environments for at least 15 minutes.

Examining Results

After 15 minutes, remove the two jars from the environments and place them together on a firm, flat surface side by side.

Observe the appearance of the balloons and jars and record what you see.

How do the two jars differ in appearance?

Did you discover anything about the relationship between temperature and pressure through this activity? If so, what did you discover?

From this activity did you develop any more information about temperature? If so, describe what type of information. What do you still need to know?

Can you relate the changes in the balloons on the canning jars to what might take place inside your ear as you go up and down a mountain or take off and land in an airplane?

Conclusion

How do you account for the changes you observe?

Background for the Teacher

The most obvious difference should be in the appearance of the balloons. The jar in the cool environment should have a concave balloon, and the jar in the warm environment should have a convex balloon. Another difference might be that the jar from the cool environment fogs up when brought into the warm environment.

Note to Teacher

The jar on the left in Figure 5-3 represents a cold environment adjustment. The jar on the right represents a warm environment adjustment.

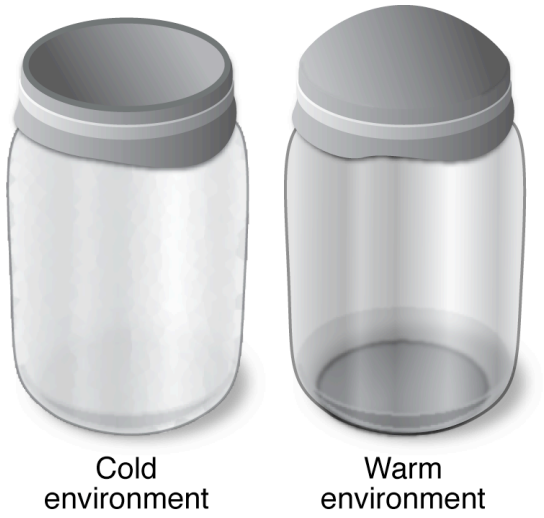

Figure 5-3. Experiment results.

If all goes as expected, the learner should concentrate on the balloons and what caused the changes. Take time to provide direction in the form of questions that guide the student in observing the jar. Developing an understanding of this important relationship is the foundation of how a barometer functions to measure air pressure. The results of this activity might be used as an inference that cold air is heavier (more dense) than warm air. Ask the student what it means when we say that the air is more dense or less dense.

Arriving at the most important outcome of this activity through careful observation and critical thinking, provoked by appropriate teacher questioning, the learner should reach the following conclusions:

The air within the jar in the warmer environment warms and expands, which causes the air inside the jar to press more firmly against the rubber balloon, thus pressing out the center. Because the air expands, it is less dense, (The number of molecules in the jar has not changed, but they take up more space. Thus, they are less closely packed, and the heated air in the jar is less dense.)

The air in the jar in the cooler environment cools and contracts, which causes the outside air to press down more firmly against the rubber balloon, thus depressing its center. Because the air contracts, it is more dense. (The molecules are more closely packed, and thus the cool air is more dense.)

Going Further

To further verify the action of the balloon and its response to air pressure, you can repeat the activity by switching the jars to the different environments to observe the results. Does the convex balloon become concave when switched to the different environment? Explain.

The results of the balloon should be the exact opposite when the environments are switched, helping to further verify the action of the balloon in response to warm and cold air.

Challenge

Research and write a paper regarding aspects of eardrum damage/changes in air travel and changes in altitude. Keep in mind that the eardrum functions like the balloon on the barometer with changes in pressure.

The learner might start with Web sites found in Appendix V.

NOTE: *This challenge singles out eardrum damage and not hearing loss in general. Therefore, the Web sites will give specific information relevant to this challenge. This challenge is important for nurturing the "scientific habits of mind" respect for data.*

For the Teacher: Example of Bringing Closure to "Think About This!"

"Think About This!" is an advanced organizer to get the learner in a mind-set to better prepare for a subsequent activity.

Bringing Closure to "Think About This!"

Look at the two jars below that form the basic structure for building a barometer.

After completing the activity you are probably aware that the air inside the jar on the left has contracted, causing the balloon to depress in the center and that the air inside the jar on the right has expanded, causing the balloon to bulge in the center.

Your eardrum is a structure that responds much like the balloon diaphragms on these jars. Both the eardrum and the barometer diaphragm expand and contract in response to changes in air pressure.

Jar A Jar B

Which balloon would be a better representation of your eardrum as you go up a mountain or reach higher altitudes in an airplane? Why? Explain.

Jar B better represents the change in the eardrum as you ascend in altitude, either by going up a mountain or rising in an airplane. The reason is that air pressure is greater at low elevations and lower at higher elevations. As you ascend, it takes some time for the interior of ear to adjust to the lower pressure; thus, the greater air pressure inside the ear, as compared with the outside environment, causes the eardrum to bulge outwardly. Jar A better represents the change in the eardrum as you decrease in altitude. At the higher altitude, the interior of the ear adjusts to the lower air pressure; during descent, the adjustment in air pressure causes the eardrum to depress and expand inwardly.